This document includes Vessels Generating Hull Coating Leachate Discharge and Overview of Discharge Analyses for the Draft "Hull Coating Leachate" report published in August 2003. The reference number is: EPA-842-D-06-002

DRAFT
Discharge Assessment Report
Hull Coating Leachate

Vessels Generating Hull Coating Leachate
Discharge and Overview of Discharge Analyses

August 2003

2 Vessels Generating Hull Coating Leachate Discharge

Some vessels of the Armed Forces do not generate hull coating leachate. As previously stated, only vessels with hulls coated to control fouling are included in this discharge. Vessels that are either unpainted or are painted with an epoxy anticorrosive coating are not included in the Hull Coating Leachate discharge. DoD estimated that 3,104 Armed Forces vessels contribute to the Hull Coating Leachate discharge worldwide. To perform the necessary analysis for assessing the regulatory options, vessels that produce hull coating leachate were sorted into three vessel groups. Additional information regarding the vessel groups and selection of representative vessel class is contained in the *Vessel Grouping and Representative Vessel Selection for Hull Coating Leachate Discharge* (EPA and Navy, 2003c).

The category with the largest wetted-hull surface area is the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group, which encompasses most Armed Forces vessels. Considerable variability in size and design is found among vessels in this group. Vessels in this group range from small boats to aircraft carriers over 1,000 feet long. The main factor in grouping these vessels is that they predominately use copper-containing antifouling coatings. For the purposes of these analyses, the USS NIMITZ (CVN 68) Class of aircraft carrier was selected to facilitate analyses for this class because:

- as a vessel type, aircraft carriers have among the greatest wetted-hull surface area of this vessel group;
- all aircraft carriers use standard copper ablative coatings; and
- the CVN 68 Class vessels are still under construction and are expected to remain in service for decades.

The second category is the Flexible (Non-Aluminum) Hulls vessel group, which consists of vessels that have hulls covered with flexible elastomeric materials. This vessel group is entirely comprised of Navy vessels that operate only in saltwater areas. Navy technical guidance requires the use of copper-containing antifouling coatings listed in Class 3A (Paint Systems having antifouling topcoats containing only copper-based toxics for use on rubber) of specification MIL-PRF-24647 for most flexible hulled vessels. The Flexible Hulls vessel group includes 58 submarines distributed among three classes and the MCM 14, a mine countermeasure vessel in the AVENGER (MCM 1) Class (Mine, 2002). Copper ablative coatings are the primary antifouling coating used on this vessel group, but these coatings are known to crack as a result of the elastomer compressing more than the antifouling coating when the vessel dives to operating depth. The cracking of these coatings is an ongoing maintenance issue. The Navy has active efforts to identify more flexible antifouling coatings for use on flexible hulls. The USS LOS ANGELES (SSN 688) Class of attack submarines was selected as the representative vessel class for this group, because:

- all submarines use standard copper ablative coatings;
- as a vessel type, submarines have among the greatest wetted-hull surface area and mass loading in this vessel group;
- the SSN 688 Class accounts for 51 of the 58 submarines in the Navy; and
- the SSN 688 Class is expected to exist for decades.

The third category is the Aluminum Hulls vessel group, which includes numerous classes of smaller vessels used by the Armed Forces ranging from less than 20 feet in length to 192 feet long. Vessels in this group primarily use non-copper coatings such as foul-release and antifouling coatings that use zinc oxide or non-metallic biocides. The U.S. Coast Guard’s (USCG) 47-foot Motor Lifeboat (MLB 47) was selected as the representative vessel class for this vessel group, because:

- all motor lifeboats that contribute to the Hull Coating Leachate discharge use advanced antifouling or foul-release coatings;
- as a vessel type, motor lifeboats have among the greatest wetted-hull surface area and mass loading of this vessel group;
- the MLB 47 Class accounts for 98 out of 403 vessels in this vessel group; and
- the MLB 47 Class vessels are expected to be in service for decades.

3 Overview of Discharge Analyses

An overview of the approach to characterizing the Hull Coating Leachate discharge and performing the feasibility and environmental effects analyses are presented in the following sections.

3.1 Characterization of Discharge

Characterizing the baseline and MPCDs discharges for each vessel group of the Hull Coating Leachate discharge was necessary to perform the environmental and feasibility analyses. Information on the release of constituents and maintenance practices and operation of vessels was needed to initiate the analyses.

Coating constituents were identified using coating manufacturers' Material Safety Data Sheets (MSDSs); while government and manufacturer studies supplied information regarding the release of certain constituents. An assumption was made that the release rate of a constituent was proportional to the weight percentage of that constituent in the coating. This allowed release rate estimates for constituents to be scaled from known metal release rates.

In addition to specific constituent data, descriptive information (e.g., color, floating materials, odor, settleable materials, turbidity/colloidal matter, etc.) is normally used to fully characterize a discharge. Hull coating leachate is not discharged from a pipe, but slowly released from the entire underwater hull of a vessel. Existing studies have not collected or reported any descriptive information. As a result, descriptive information is not reported in this document. Due to the rate and nature of the constituents released, this discharge is expected to have negligible affects on parameters related to narrative water quality criteria.

A variety of information was necessary to quantify the magnitude of the discharge. Information from service representatives and equipment experts were used to identify the coatings used on each vessel class. Vessel movement information was obtained from the Uniform National Discharge Standards Management Information System (UNDSMIS) database to determine when vessels contribute to the discharge (i.e., days in port, days in transit) and at what rate (i.e., dynamic release rates when vessels are in transit, static release rates when vessels are pierside). Knowledge regarding vessel use and operation was also required when quantifying the amount of hull coating leachate. A detailed description of the coating constituents and release properties resulting from hull coating leachate is presented in the *Hull Coating Leachate ChAR* (Navy and EPA, 2003a).

3.2 Potential Marine Pollution Control Device Options and Screen Results

Potential MPCD options to control Hull Coating Leachate were identified through a variety of sources including current practices of Armed Forces vessels and commercial vessels as well as literature and Internet searches. Four MPCD options were identified and screened to determine which MPCDs have been sufficiently proven for controlling hull coating leachate. A brief description of each MPCD option and the results of the screen are provided below.

3.2.1 Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings

For Armed Forces vessels coated with antifouling products qualified under the military specification MIL-PRF-24647, the biocide released into the water to prevent the growth of marine fouling organisms is the copper from cuprous oxide or other copper-containing compounds included in the coatings (Navy, 2001). This MPCD option group would establish a maximum allowable copper release rate from copper-containing antifouling coatings. A numerical maximum allowable copper release rate standard would be based on the results of ongoing Navy testing using the American Society for Testing and Materials (ASTM) D 6442, *Standard Test Method for Copper Release Rates of Antifouling Coating Systems in Seawater*. If this MPCD option group is chosen, it will prevent the use of higher release rate copper-containing coatings in future applications.

Once the maximum allowable copper release rate is established, the limit would be applied to current and future antifouling coatings. Coatings that emit more copper than allowed, as measured using the ASTM-D-6442 test method, would be prohibited from use on Armed Forces vessels.

A precedent exists for establishing a maximum allowable release rate for copper. In 1994, Canada established a copper release rate of 40 $\mu g/cm^2$/day for all coatings being registered through Health Canada (Health Canada, 1994). Sweden also established a copper release rate of 55$\mu g/cm^2$/day for all vessels operating in the Baltic and North Sea areas (International Coatings, 2000).

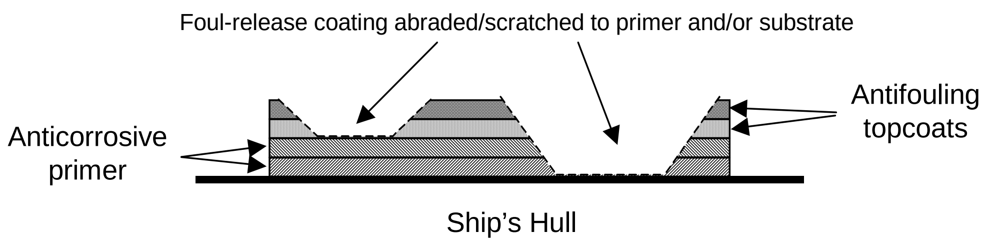
The establishment of a maximum allowable copper release rate for antifouling coatings has been demonstrated in foreign countries. Therefore, this MPCD option passed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.2 Foul-Release Coatings

A standard based on the foul-release coatings MPCD option would mandate the use of foul release coatings on all vessels within an appropriate vessel group. The foul-release coating approved for Armed Forces vessels is a soft flexible material based on silicone polymers that uses surface chemistry to inhibit adhesion of fouling organisms to the hull coating. This coating exhibits a low surface energy and is applied as extremely smooth layers, such that any marine organisms that grow on the hull can be released or dislodged by the flow of water over the hull as the vessel achieves a critical speed (i.e., usually in excess of 15 knots). Foul-release coatings do not release biocides to control fouling (NRL, 1997).

Foul-release coatings have no means of preventing the growth of marine fouling organisms (e.g., algae, mollusks, worms, etc.) while vessels are pierside. As little as two weeks of vessel inactivity (i.e., no instances of operations above the critical speed for fouling release) in high-fouling areas (e.g., Miami, FL and Ingleside, TX) can result in build-up of marine fouling organisms on a vessel's hull requiring a complete hull cleaning (International Marine Coatings, 2001). Because vessel motion is required to dislodge the marine fouling from the hull, vessel speed is an important factor when considering the vessel classes or types that can successfully use foul-release coatings. When the vessel's operational profile does not provide sufficient operating time and speed to dislodge fouling organisms, underwater hull cleaning is usually required (International Marine Coatings, 2001; Hempel, 2001; Marlin Paint, 2001). Even careful cleaning of the soft foul-release coatings can result in scratch damage that could negatively affect their efficacy. Scratches from cleaning or abrasions from fenders or tugs can expose the epoxy primer or substrate under the foul-release coating as shown in Figure 3-1. These damaged areas will foul, and a more significant cleaning effort will be required to remove organisms from the epoxy substrate, resulting in a greater degree of damage to the foul-release coating. Thus, the degradation of the coating accelerates and the efficacy of it declines rapidly once the surface smoothness has been compromised.

Figure 3-1. Damage to Foul-Release Coatings



Foul-release coatings are currently approved for use on Armed Forces vessels in accordance with MIL-PRF-24647. Intersleek 425 foul-release coating is currently used on a limited number of Navy and Coast Guard vessels. Therefore, this MPCD option group passed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.3 Advanced Antifouling Coatings

The advanced antifouling coatings MPCD option would mandate the use of such coatings on all vessels within a vessel group. Advanced antifouling coatings release short half-life biocides into the water surrounding the vessel hull to prevent the growth of marine fouling organisms. Some advanced antifouling coatings contain copper and a non-metallic co-biocide, while others are based on combinations of non-metallic biocides (e.g., Sea-Nine211®). Advanced antifouling coatings are currently being tested on Armed Forces vessels. The USCG has approved one copper-free antifouling coating for use on smaller USCG vessels with aluminum hulls. The USCG-approved, copper-free coating performs effectively for less than two years in high fouling areas such as Florida. At present, advanced antifouling coatings have been shown to foul too quickly and do not satisfy the Navy performance requirements in MIL-PRF-24647 (Lawrence, 2003). In the case of advanced antifouling coatings that use copper as a co-biocide, the Navy has stated that the advanced antifouling coatings should emit less copper than is currently released from the copper-ablative products approved under MIL-PRF-24647 to be considered an environmentally acceptable product by the Navy (Ingle, 2002).

Advanced antifouling coatings are currently approved and used on USCG aluminum small boats and craft. Future technological advances may allow the use of these coatings on ships that use copper ablative antifouling coatings. Therefore, this MPCD option group passed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.4 Non-Coating Methodologies

The non-coating methodologies MPCD option group included alternative methods, devices, or equipment that claim to eliminate or minimize the discharge of hull coating leachate by replacing conventional hull coatings. The methodologies and devices reviewed are grouped in the seven categories: (1) electrical & electrochemical devices, (2) acoustic and ultrasonic devices, (3) radiological devices and treatments, (4) surfaces with micro and/or macroscopic topology, (5) containment systems, (6) metal spray/claddings, and (7) alternative alloy hulls.

Non-coating, fouling-control methodologies and devices have not been proven effective on modern commercial or Armed Forces vessels. Therefore, this MPCD option failed the MPCD screen as outlined in the *Marine Pollution Control Device Screen Criteria Guidance Document* (EPA and Navy, 2000b).

3.2.5 MPCD Screening Results

A summary of the MPCD options identified and the outcome to the MPCD analysis are presented in Table 3-1.

Table 3-1. Hull Coating Leachate MPCDs Identified

MPCD	Result
Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings	Pass
Foul-Release Coatings	Pass
Advanced Antifouling Coatings	Pass
Non-Coating Methodologies	Fail

Additional information on these MPCD options and the screen analysis can be found in the respectively titled MPCD screen reports (EPA and Navy, 2002a, 2003a, 2003b, and 2003d).

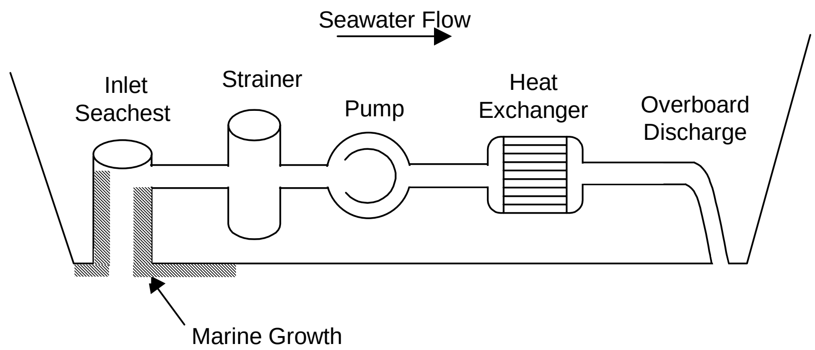
3.3 Feasibility Impact Analysis

The analysis of discharge information and presentation of results in this report are in accordance with the methodology contained in the FIAR guidance manual (Navy and EPA, 2000b). Five feasibility factors were applicable to the Hull Coating Leachate discharge including one factor (i.e., drydocking interval and pierside maintenance factor) identified as unique to this discharge:

- Mission Capabilities,
- Drydocking Interval and Pierside Maintenance,
- Initial Costs,
- Recurring Costs, and
- Total Ownership Costs.

Vessel operational area and mission influence the selection of hull coating system. The potential impact that each MPCD would have on each vessel group was analyzed after obtaining information from shipyards and technical experts. The feasibility analysis explores the effect of each MPCD option on a vessel's mission capabilities. In addition to coatings being applied to hulls, the seachests on some vessels are coated with the hull paint system. Any changes to the hull paint system have a direct impact on marine growth surrounding the seachest and the related ship systems. Increased growth in the seachest area may enter the seawater system affecting the operation of the ship heat exchanger and the systems they support as illustrated in Figure 3-2.

Figure 3-2. Typical Seawater System



The feasibility analysis also examines the change in vessel drydocking cycles and required pierside maintenance. Each MPCD option has a different service life and could result in drydock and maintenance cycle changes.

The final step of the feasibility analysis estimates costs for implementing each of the MPCD options. Costs include modifications to the existing military specifications, manuals, and contracts as well as direct expenses for the preservation of ships (i.e., drydocking, procurement of coatings, disposal of solid waste, and any other coating related expenses).

A more detailed discussion of the feasibility impact analyses is included in the *Hull Coating Leachate FIAR* (Navy and EPA, 2003b).

3.4 Environmental Effects Analysis

The environmental effects analyses (EEA) entail seven tasks that are summarized below. The specific analyses to be performed are outlined in the *Environmental Effects Analyses Guidance* (EPA and Navy, 2000a).

3.4.1 Comparison to Water Quality Criteria

From the information contained in the *Hull Coating Leachate* ChAR, a series of analyses were conducted. Constituents were identified with estimated concentrations at 1 cm from the hull that exceeded any State or Federal numeric acute or chronic water quality criteria standards. Due to the lack of descriptive (i.e., narrative) data, comparisons to narrative water quality criteria standards were not conducted. Due to the rate and nature of the constituents released, this discharge is expected to have negligible affects on parameters related to narrative water quality criteria.

3.4.2 Discharge Toxicity

The toxicity of the discharge was evaluated by estimating acute marine aquatic-life toxicity at the 35m edge of the mixing zone. For the Hull Coating Leachate Discharge, transect data around a hull was available and used in place of modeled data to estimate concentrations at the 35m edge of the mixing zone to calculate the Hazard Index.

3.4.3 Identification of Bioaccumulative Contaminants of Concern

Coating constituents were identified that are included on the list of bioaccumulative contaminants of concern (BCCs) designated for reduction by U.S. permit and clean-up programs.

3.4.4 Mass Loadings/Toxic Pound Equivalent

Mass loadings were calculated for active vessels of the Armed Forces homeported in the U.S. while in port and while underway within 12 nm using constituent static and dynamic release rates, vessel time pierside and in transit, and vessel coating usage information. The length of the vessel was also an important factor, because vessels less than 25 feet in length are frequently pulled out of the water during the time pierside and do not contribute to loadings while they are out of the water. The mass loadings were used in conjunction with toxic weighting factors to calculate toxic pound equivalent (TPE) loadings.

3.4.5 Release of Nonindigenous Species

A qualitative evaluation of the baseline discharge and MPCD options' potential to introduce nonindigenous species of plant and animal life into new environments is an important factor for the environmental effects analysis.

3.4.6 Other Potential Environmental Effects

In addition to constituent analyses, other potential environmental impacts of the discharge were identified. These impacts include any additional air releases, solid waste generation, or energy requirements of the options.